Homework 2

EECS 270 Winter 2020

Due Friday, January 31 @ **11:59 PM** on Gradescope

This is an individual assignment, all of the work should be your own.
Write neatly or type and show all your work for full credit.
Have your name and unique name on the front page of your submission.

1. **[30 points]** Using only algebraic manipulation, in the style covered in lecture, verify each of the following equalities, stating all postulates and theorems (with their number and name if they have one) you use in your verification:
   a. $x(x + x'y)' = 0$
   b. $bc + ab' + ((ab' + ab)' + c')' = bc + ab'$
   c. $(xyz + x'y)' = y' + xz'$
2. **[10 points]** Use Shannon's Expansion Theorem to expand the equations, simplifying the co-factors:
   a. $f = xyz + x'y + x'y'z' + x'yz$, expand around x
   b. $f = x'z' + xyz + x'y'z + x'yz'$, expand around y, z
3. **[10 points]** Let f' and f^d denote the complement and dual, respectively, of function f. Let function $g = xy + yz + zx$.
   a. **[3]** What is g'?
   b. **[3]** What is g^d?
   c. **[4]** A function f is self-dual if $f = f^d$. Is function g self-dual?
4. **[10 points]** Assume for a particular year that a particular size chip using state-of-the-art technology can contain 2 billion transistors. In 7.5 years, assume Moore's Law (the number of transistors on integrated chips doubles approximately every 18 months) holds:
   a. **[5]** How many times smaller would a chip containing the same number of transistors be?
   b. **[5]** How many transistors would a chip of the original size be able to contain?
5. **[15 points]** Let variable S represent a package being small, H being heavy, and E being expensive. Write a Boolean equation to represent the following:
   a. **[5]** Your company specializes in delivering packages that are both light and inexpensive (a package must be light AND inexpensive for us to deliver it); you'll also deliver packages that are heavy but only if they are expensive.
   b. **[5]** A particular truck can be loaded with packages only if the packages are small and heavy, big and light, or small and light. Simplify the equation.
   c. **[5]** Your company's only truck was able to carry any package. However, it has been destroyed and your company buys the truck in (b) to replace it. With your company's delivery policy from (a) and the capabilities of the new truck from (b), what packages are your company restricted to delivering? Simplify the equation. (hint: appropriately combine the equations from the above two parts.)
6. **[12 points]** Convert the function F shown in the table below to SOP and POS, in both short-hand (e.g. $\sum(1, 2, 3)$) and algebraic (e.g. $a'b'c' + a'bc'$) formats.

a	b	c	F
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

7. **[13 points]** For $F = a + (a' \oplus b)$, do the following:

   a. **[7]** Derive the truth table for equation F, using the format from (6).

   b. **[6]** Directly convert equation F into a gate-level digital circuit (do **not** perform any optimizations). [*Looking for a drawing program to use? Draw.io is a simple web-based tool that can draw logic diagrams quickly!*]